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ABSTRACT

An individualized motivation system was used to increase the performance of three students using a computerized number facts program. Previous research on number facts suggested that performance increments might occur through massive practice and/or changes in processing ability. In this study, points exchangeable for extra gym time were contingent upon daily individual accuracy increases of 5% or a rise to 95% accuracy or higher. A multiple baseline design was used and each student showed increases in accuracy rate and items attempted. In addition, improvement was also seen on an independently administered paper and pencil test. It is suggested that similar procedures be considered for other students requiring remedial academic work. (Author/CH)

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The Use of an Individualized Motivation System to Modify Accuracy and Rate on a Computer-Based Number Facts Program

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Abstract

A low-cost, individualized motivation system was used to increase the performance of three students using a computerized number facts program. Previous research on number facts suggested that performance increments might occur through massive practice and/or changes in processing abilities. In the present study, points, exchangeable for extra gym time, were contingent upon daily individual accuracy increases of 5 percent, or a rise to 95 percent or higher. A multiple baseline design was used and each student showed increases in accuracy, rate and items attempted. In addition, improvement was also seen on an independently administered paper and pencil test. It is suggested that similar procedures be considered for other students requiring remedial academic work.

The Use of an Individualized Motivation System to Modify Accuracy and Rate on a Computer-Based Number Facts Program[1]

During the past five years an increasing number of applied classroom investigations have focused on student academic performance (e.g., Fink and Carnine, 1975; Klein and Gray, in press; Stromer, 1975). Research on academic behavior has examined student performance in a variety of curriculum areas, (e.g., arithmetic, spelling, reading), and the curriculum materials have been presented to the students through a number of different types of delivery systems (e.g., programmed tasks, Greenwood, Sloane and Baskin, 1974; textbooks, Harris and Sherman, 1974; teacher or experimenter designed worksheets, Van Houten, Morrison, Jarvis and McDonald, 1974).

One delivery system which has not been explored extensively in conjunction with applied behavior analysis is the computer. Computers can provide highly individualized training, which supposedly maximizes the motivational/instructional process (Jacobson, 1975). The present study examined the use of an individualized contingency system to accelerate performance on a computer-based number facts curriculum. The mastery of number facts (i.e., the application of arithmetic operations to single digits and the associated outcomes of these operations) is considered essential to the learning of more complex mathematical tasks. In spite of the importance of number facts and a variety of methods designed to optimize number fact drills (e.g., Lindvall & Bolvin, 1966; Suppes, Jerman, & Brian, 1968) student performance in this area remains a chronic problem in elementary schools (Jacobson, 1975).

One approach to this problem has been through the use of the computer (e.g., Jacobson, 1975; Tait, Hartley, & Anderson, 1973). Although the

computer has facilitated training it has still been observed that many students continue to perform at accuracy rates too low to enable successful higher-level problem solving (Jacobson). To date, little in the way of practical suggestions for improving number fact performance have been offered, other than the continued use of massive practice. Because extensive practice can become monotonous, and problems of attention can develop (Tait et al.,), maintaining the motivation of the learner would appear to be extremely important.

Method

Subjects and Setting

The subjects were three fifth-grade students (S_1, S_2, and S_3) in a suburban Pittsburgh public school. The school uses the Individually Prescribed Instruction (IPI) arithmetic curriculum. A part of this curriculum called the FACTS program is devoted to the acquisition and maintenance of number facts. The S's had previous experience with this program, having successfully completed an assessment and instruction phase. This study examined S's performance during a practice phase, in which quick associative recall is developed. Each S was selected for the study by the classroom teacher who believed that S's progress in number facts was unsatisfactory. Progress in number facts is assessed in three ways: Daily performance on the FACTS program, performance on a timed (five minute) paper and pencil test which samples number facts from the computer program, and is given periodically to all students, and performance on daily workbook problems which make use of number facts. In the present study only the first two measures were examined, and S's were considered to have mastered number facts when performance on both of these measures was at 96% accuracy or higher. Once this level is achieved students stop using the FACTS program and return to it only if the teacher detects reduced performance in workbooks or a paper and pencil facts test.

Materials

The FACTS program utilizes a medium-sized computer consisting of a Digital Equipment Corporation PDP-15, a high speed drum storage device, and slower speed disc stores. Computer terminals are located in two separate areas immediately outside the classrooms. The terminal used for the FACTS program is the Datapoint 330. Students have been trained to use the terminals and access programs independent of adult supervision.

The FACTS program practice phase attempts to insure that students can quickly recall the answers to specific problems in addition, subtraction, multiplication and division, taught during the acquisition phase. The present study dealt only with student performance in division. During practice the program uses a random generator to present number facts. A record is established by the program for each student so that individual number facts are presented based on a combination of previous performance and the random generator. The problems presented most often are those missed most often, although presentation of all number facts is maintained.

For each student the practice phase sequence consists of a problem appearing on a television-like screen, the student reading and typing in an answer, and then receiving immediate feedback concerning accuracy. If the student's answer is wrong the program erases the answer and prints the correct answer in its place. Another problem is then selected by the program and the sequence begins again.

Recording Procedures and Reliability

Each recording session was programmed to be 10 minutes in length from the point at which S accessed the FACTS program. A hardcopy output of each S's daily performance was produced by FACTS. The data consisted of number of

items correct and incorrect, percent correct, and rate of computation in seconds and tenths of seconds. Because students were not assigned any specific number of problems on a daily basis, accuracy was based on number correct ÷ number attempted. A contingency was applied to number of problems attempted, during treatment, to prevent an increase in accuracy from occurring simply by S's reducing attempts (see Klein, 1975).

Each S received a copy of his performance at the end of every session. S recorded all performance measures on a data collection sheet. The sheet also had a column where points could be entered by S once the treatment phase began. Another copy of the output was retained by the second experimenter. Reliability checks indicated that all S entries, throughout the study, including points earned, corresponded 100% with experimenter calculations.

Procedure

A multiple baseline design was used in which treatment was introduced on a staggered basis, after 12 baseline sessions for S_1, after 29 sessions for S_2, and after 44 sessions for S_3. Treatment lasted 36 sessions for S_1, 23 sessions for S_2, and 11 sessions for S_3.

Baseline. On the first day of baseline each S was given the number-facts paper and pencil test. During baseline S's were requested to spend 10 minutes per day on the FACTS program. After completing the 10 minute session each S recorded the summary data and returned to the classroom. Occasionally, throughout baseline and treatment, absences and computer breakdowns prevented S's from participating in a daily session. On the last day of baseline for S_1 all S's were again given the paper and pencil facts test.

Treatment. It was explained to each S at the end of their respective baselines that they could earn up to one additional gym period per

week (30 minutes with a cooperating fifth-grade teacher), for improved number fact performance. The contingency was individualized so that each S could earn one point per day for showing either a 5% gain over his/her previous day's percent correct, or a rise to 95% or higher. To insure that S's did not reduce the number of problems attempted, in order to achieve a high percent, each S was required to attempt a minimum number of problems. For S_1 the minimum was set at 32 problems, while for S_2 and S_3 the minimum was 35 problems attempted. Each point was exchangeable for six minutes of gym time on Friday. Time could accumulate for more than one week up to a maximum of 30 minutes. Aside from the contingency the daily procedures described in baseline remained in effect. On the last day of treatment each S was given the paper and pencil number-facts test.

Results

Each S showed marked improvement in accuracy, items attempted, and rate on the FACTS program. The multiple baseline design successfully demonstrated that the performance changes were a function of the treatment since each S improved only at the point at which the contingency was introduced. As seen in Figure 1, accuracy for S_1 showed a baseline average of 73.5% with seven of the 12 sessions showing accuracy levels of 75% or lower.

Insert Figure 1 about here

When treatment was introduced a sharp increase in accuracy took place immediately, and S_1 maintained a 94.2% average on this variable until the end of the experiment. In contrast to baseline data for S_1, on only four sessions was accuracy below 90% and only once was it below 85%.

More importantly, during the last 12 days of treatment accuracy for S_1 averaged 97.2%, which was above the level needed to master the program.

Accuracy data for S_2 and S_3, also shown in Figure 1, demonstrate equally substantial changes. S_2 had a baseline mean accuracy level of 72.5%, with 12 of 29 baseline sessions at 75% or below. Treatment, however, produced a mean accuracy level of 96% with only one session below 90%. S_3 had the highest mean baseline accuracy data, with an average of 89.4%, and only six sessions showing accuracy at or below 75%. Treatment raised the average to 98.9% with only one score as low as 95%.

The mean number of items attempted per session also increased for each S from baseline to treatment. S_1 attempted a mean of 23.6, S_2 a mean of 18.4 and S_3 a mean of 19.5 problems per session during baseline. During the treatment phase these means increased for each respective S to 40.4, 39.4 and 36.4 per session. In order to receive reinforcement S_1 was required to attempt at least 32 problems per session, while S_2 and S_3 needed to attempt at least 35 problems. S_1 lost the opportunity to earn reinforcement on only four sessions, while S_2 lost on five sessions and S_3 on one, for failure to meet the minimum attempts criterion.

In addition to a minimum attempts criterion, each S also had to show an accuracy increase of at least 5% over the previous session, or a level of 95% or above, in order to earn points. S_1 met this criterion on 22 of 36 sessions, including 14 of the last 15 treatment sessions. S_2 met the accuracy criterion on 17 of 23 sessions including 16 of the last 17 sessions. S_3 met the accuracy criterion during all 11 treatment sessions.

As seen in Figure 2 rate of computation was accelerated for each S once treatment conditions were introduced.

Insert Figure 2 about here

S_1 who averaged 15.7 seconds per problem in baseline, averaged 8.6 seconds per problem during the treatment phase. In fact S_1 had only seven sessions during treatment in which the mean computation rate per problem exceeded 10 seconds. S_2 showed a reduction from a mean of 17.4 seconds per problem in baseline to 8.5 seconds per problem in treatment. S_2 showed only four sessions in treatment where the mean rate was greater than 10 seconds per problem. S_3 reduced her mean calculation rate from 16.8 to 9.8 seconds per problem, from baseline to treatment. S_3 also had only two sessions in which the mean rate exceeded 10 seconds per problem.

When the S's were given the paper and pencil number facts test on the first day of baseline, each S took the full five minutes to complete the test. Accuracy levels were 56% for S_1, 40% for S_2 and 78% for S_3. When the second test was given, at the end of baseline for S_1, accuracy levels were 44% for S_1, 84% for S_2 and 100% for S_3. In addition, S_3 spent only 3 minutes and 55 seconds on the test, while S_1 and S_2 took the full 5 minutes. Thus, performance decreased for S_1 but improved for S_2 and S_3, in spite of continued poor performance by all three S's on the FACTS program. On the last day of treatment all S's showed marked improvement on the paper and pencil test. Accuracy for S_1 was 96%, and 100% for S_2 and S_3. In addition, each S now completed the test in well under five minutes. S_1 worked for 3 minutes, 48 seconds, S_2 3 minutes, 28 seconds, and S_3 2 minutes and 51 seconds. All S's were permitted to terminate use of the FACTS since accuracy criteria were met for both the computer program and the paper and pencil test.

Discussion

It was shown that a low-cost individualized motivation system can be combined with a computer program to maximize student number fact performance. Students who were performing below acceptable criterion levels were able to master the program and terminate the practice phase. While it has been suggested that for some students number fact performance may reach a plateau and then improve only with age, massive practice, and/or changes in processing abilities (e.g., Jacobson, 1975), the present research suggests otherwise.

While mastery was achieved several findings need elaboration. Two of the subjects did show improvement on the paper and pencil test after the S_1 baseline was over, while one subject showed a decrease on this test. The paper and pencil findings for the two improved subjects were not corroborated by either the accuracy or rate measures on the FACTS program. In fact, some decline was seen in program accuracy for S_2 and S_3 during the latter stages of their baselines. Since the paper and pencil test is just a sample of the FACTS program it is conceivable that the improvement for S_2 and S_3 were sampling errors. It is also possible, however, that baseline practice produced the improvement.

It should also be noted that the individualized reinforcement system, which was designed specifically for low-performing students, (see Reiss Klein and Reiss, 1974) produced a dramatic increase in S_1 and S_2 on the first day of treatment. Because the improvement was so great these two S's were virtually forced to perform from the second day of treatment at the 95% level, or higher, in order to continuously earn points. This was accomplished after six days by S_2, but S_1 required about one-half of the

treatment period in order to consistently earn points. Shortly after treatment was introduced for S_1, consideration was given to lowering the accuracy criteria so that more points could be earned. This, however, was not done and S_1 ultimately performed at the required level.

Although S_1 persisted until points were regularly earned other students might not have done so. Certainly, when baseline data show the type of wide variability demonstrated here, it might be expected that relatively high performance will be achieved almost immediately upon the introduction of treatment. If contingencies then require continued 5% increases, or very high performance, it may prove difficult for some students to maintain such levels. It appears that S_1 experienced this problem, and while overcoming it, the present system might not have been optimal for S_1. It is maintained that for very low performing students, with stable baselines, the present system probably is helpful since it permits all students to earn an equivalent amount of reinforcement for similar 5% performance increases (Reiss et al., 1974). Future research needs to more thoroughly examine the effects of such systems on different student populations.

Finally, the success of this treatment program suggests that further examination be given to the combined use of computer programs and contingency systems. Such applications may prove most beneficial for children needing remedial academic work.

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FOOTNOTES

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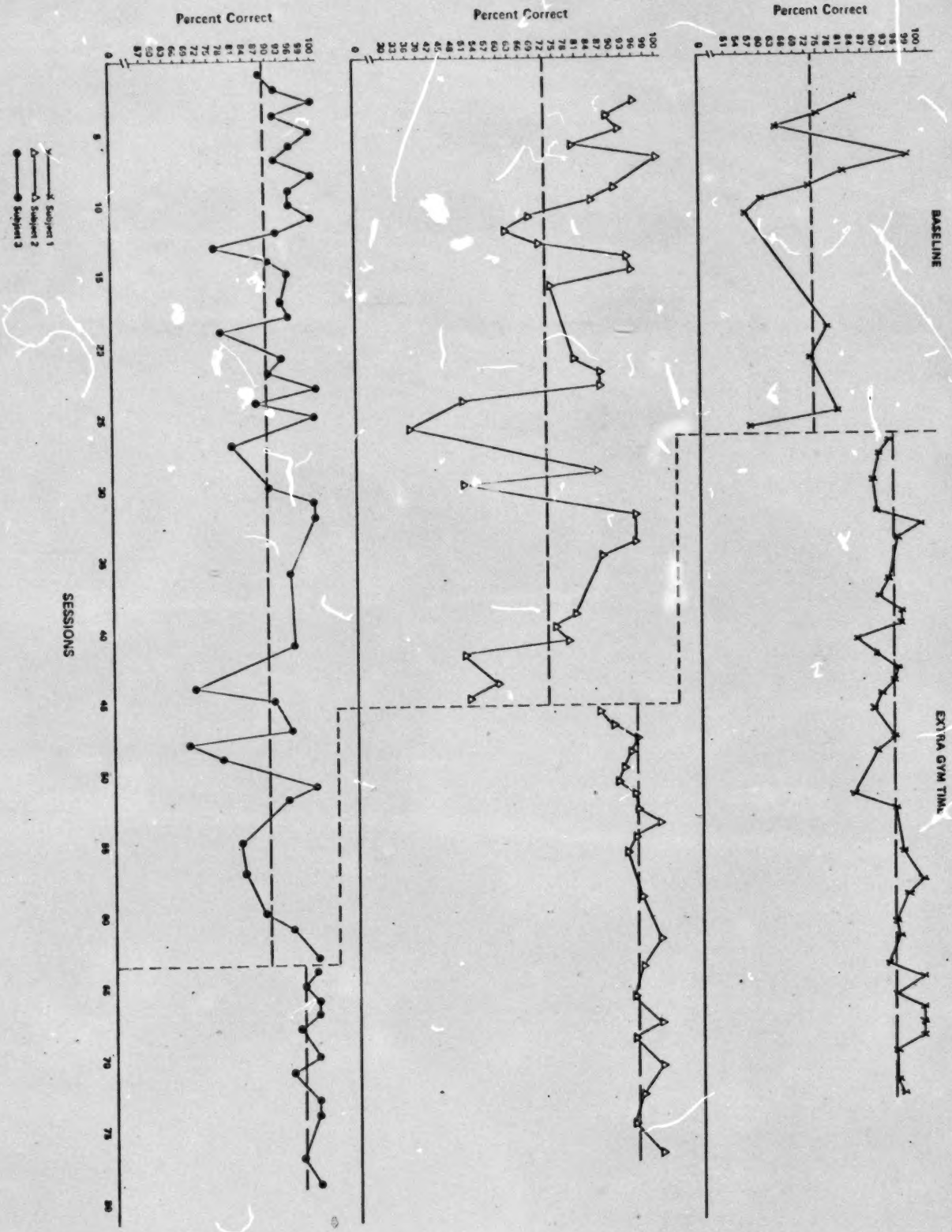
Figure Captions

Figure 1. Percent correct for each S for every baseline and treatment session on the number facts program.

Figure 2. Mean seconds of computation time per problem for each S for every baseline and treatment session on the number facts program.


Percent Correct
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BASELINE
EXTRA GYM TIME
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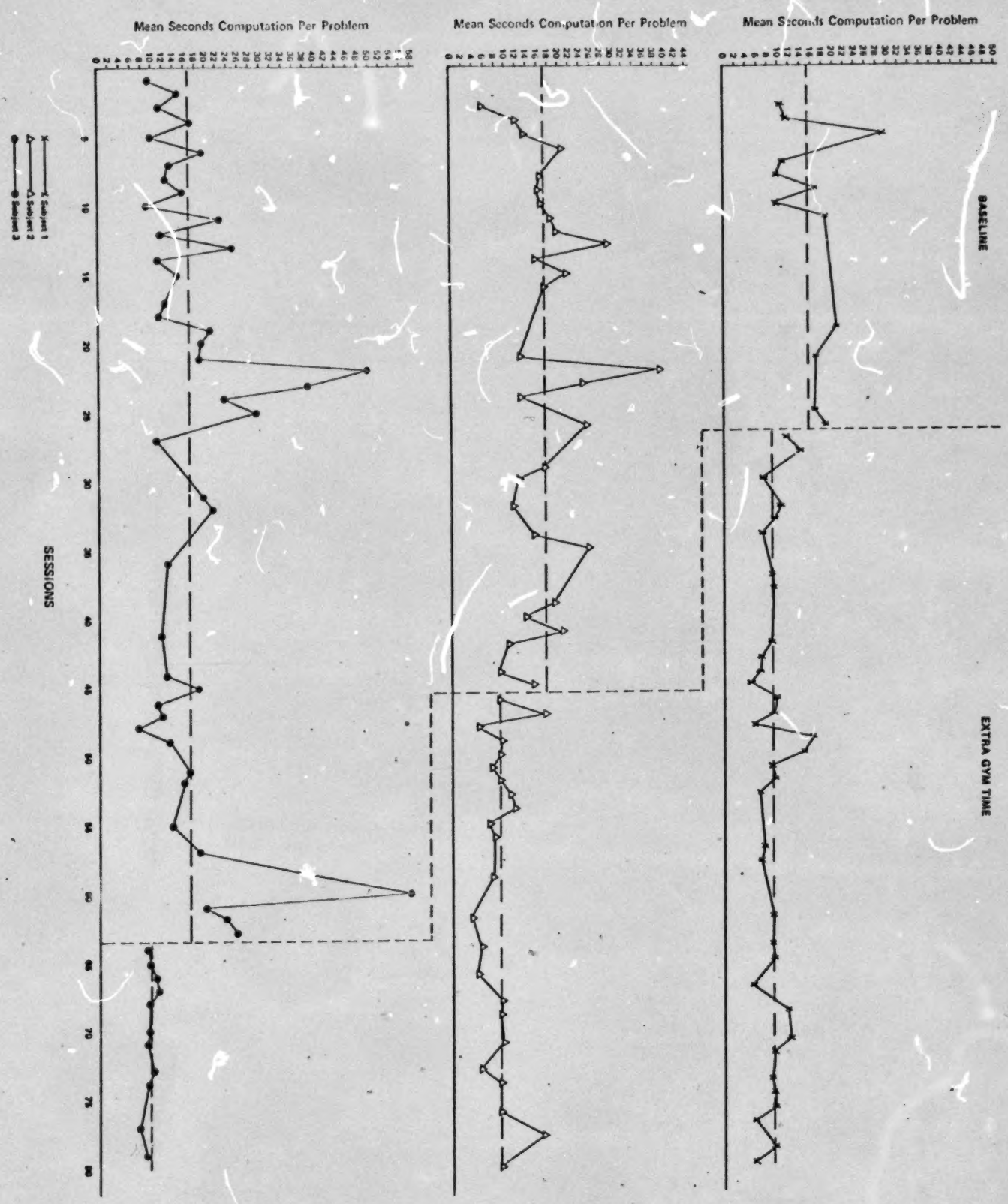
Subject 1
Subject 2
Subject 3


Mean Seconds Computation Per Problem
Mean Seconds Computation Per Problem
Mean Seconds Computation Per Problem
BASELINE
EXTRA GYM TIME
SESSIONS
Subject 1
Subject 2
Subject 3